WBS 1.3 Liquid Argon Calorimeter

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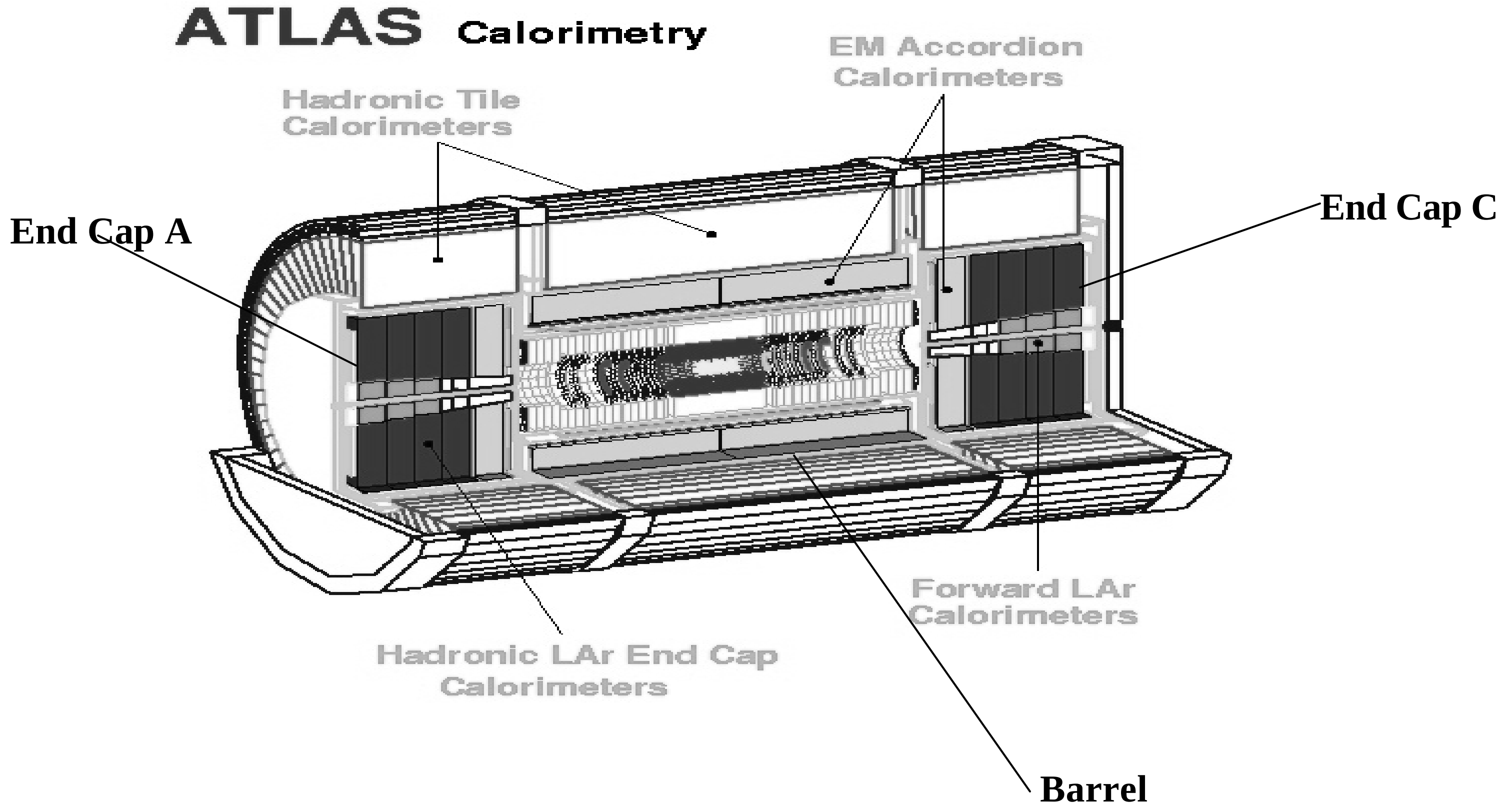
SMU

Outline

- Organizational Changes -none
- Technical Status
- Cost and Schedule Status (as of 12/01)
- ETC02 Cost and Schedule Changes
- Installation Details
- Conclusions
- Operation and maintenance

Liquid Argon Calorimeter

Barrel



U.S. deliverables

- Refrigeration system
- Argon quality monitors
- Signal feedthroughs
- HV feedthroughs
- Front end crate system and warm cables
  - Pedestals
- Barrel cryostat
  - Base planes
  - Cables
  - Cooling system
  - Slow controls
- Electrodes for the electromagnetic modules

U.S. deliverables 2

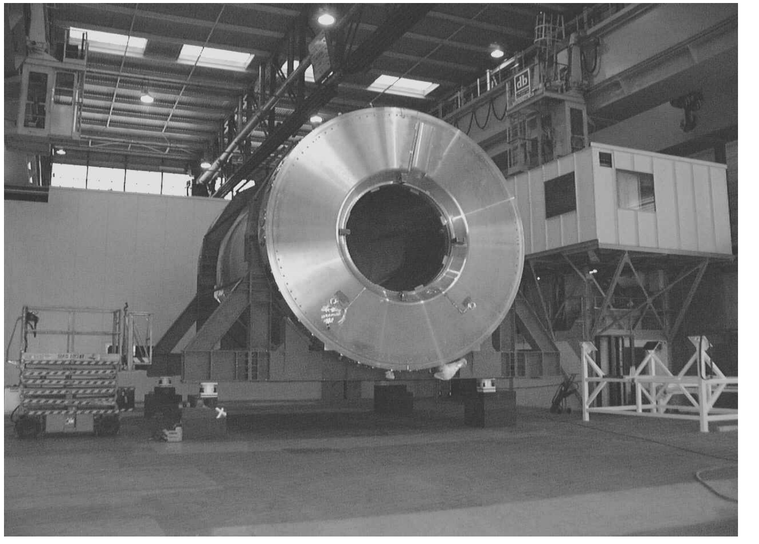
- Motherboards system for EM modules:
  - Mother boards, summing boards, calibration network, protection circuit
- Front End boards
  - Preamps, Asics, Layer Sum boards
- Optical links
- Level 1 trigger receiving system
- Readout Drivers (ROD)
- Forward Calorimeters
- Test beam
- Slow control and detector software

Technical Status

- **I will discuss technical status first as it will be easier to explain the budget and schedule changes**
- **Overall – production of LAr components for which US has major responsibility is in good shape**
- **Schedule and installation is driven by factors outside of US control and may slip by several month**
- **Cost for ETC02 is almost identical with that for ETC01**

Barrel Cryostat

US is providing:
Design
Cold vessel (for calorimeter modules)
Warm vessel (solenoid)
Flanges, bulkheads, etc.
Insertion tools
Installation components
Slow controls



Barrel Cryostat

Status – **delayed**

provisional acceptance

- in bldg 180 since summer 2001(on time)

- pressure tests found a small leak in the chimney weld on the bulkhead

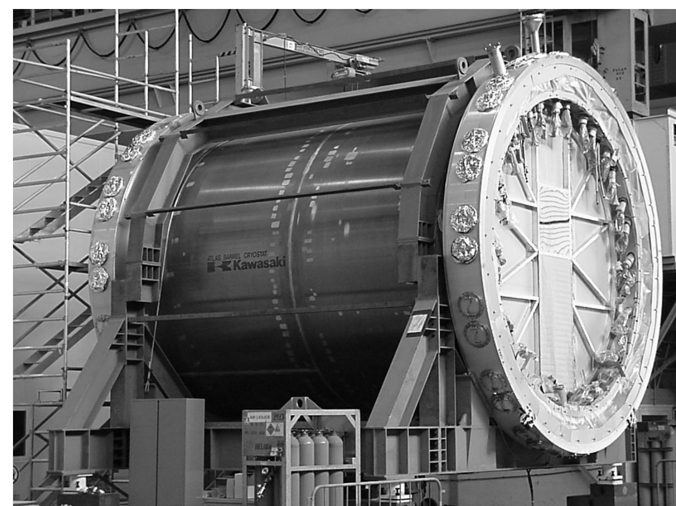
- 7 month of discussion between BNL, CERN and Kawasaki how to fix it

-final agreement: repair in March by ***butter weld* –** refill of the affected area

- pressure tests in May

- final acceptance in June

- no impact on schedule: work on feedthroughs installation proceeds well



Cryogenics

US is providing:

Refrigerator (located on the surface)

Nitrogen Dewar (located in the pit)

Interconnects

LN2 Quality Meters

Slow controls: temperature and pressure sensors, flow meters, etc.

•US will buy components, participate in commissioning and in installation.

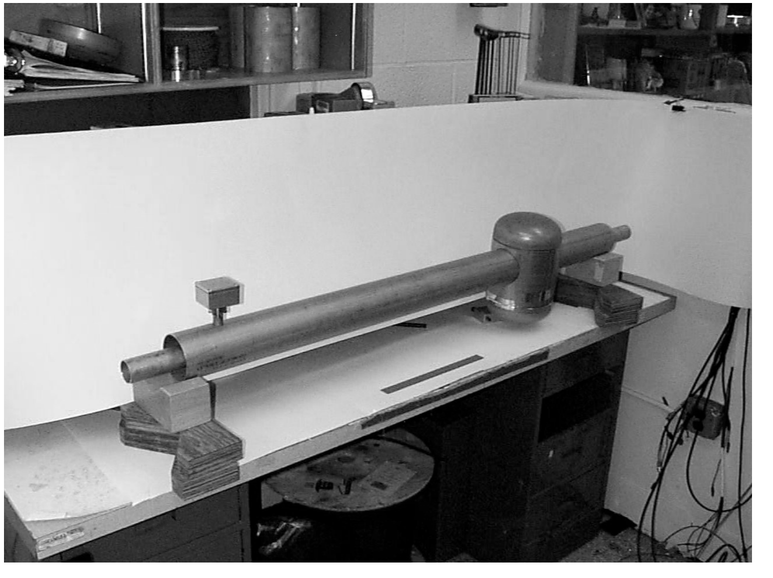
•Engineering contribution to the integration: both in commissioning stage and in the pit, safety protection, etc.

•Control and monitoring software

Cryogenics

Status of the LN2 system:

- •design complete
- •Air Liquide (France) selected for manufacturing
- •Apparent delay caused by the CERN schedule slip for the experimental hall availability
- •Work concentrated on design of software control system
- •Quality meters
  - •measure gas/liquid ratio with 5% precision
  - •18 units built at BNL
  - •“fill-time”production will be ready for summer



Signal Feedthroughs

High density connectors and cables to transfer signals from cold to warm

US is providing:

Overall design

Production of 64 Barrel Feedthroughs +spares

Components for Endcaps feedthroughs production

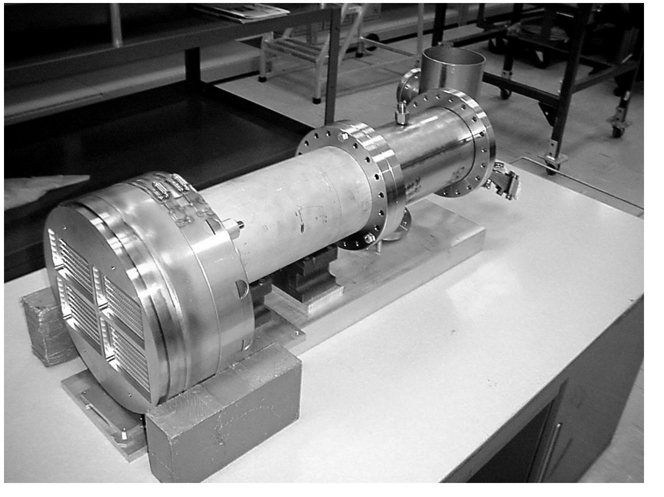
Installation

Commissioning

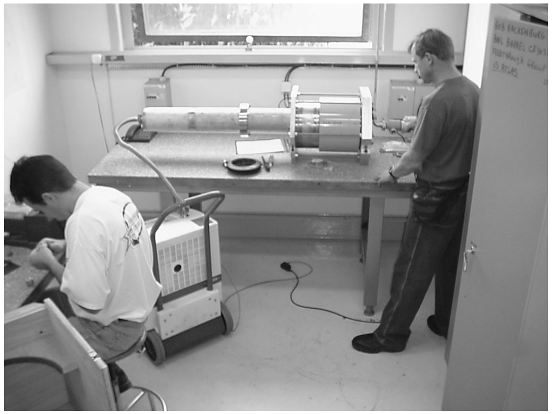
Slow controls

- temperature, pressure, gas flow

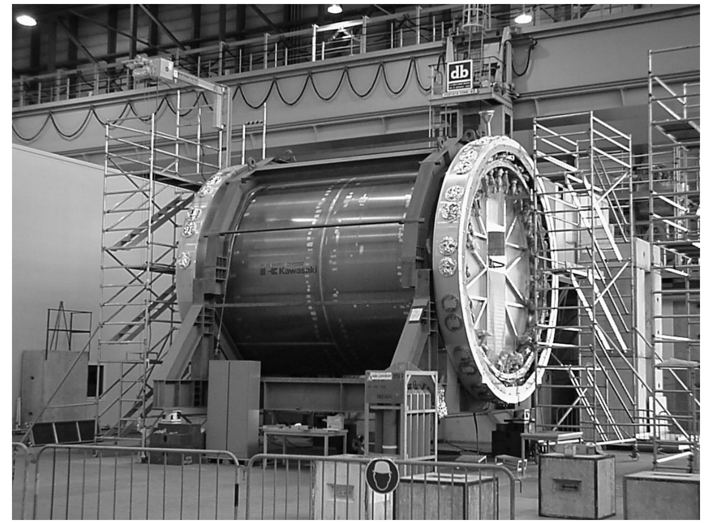
Engineering support



Signal Feedthroughs 2



Vacuum test at BNL



FTs Installed on the cryostat

Ready for installation

Signal Feedthroughs 3

- Last year's problem with the pin carriers solved in Spring 01
- Production factory set up at BNL (Tom Muller et al.)
- Installation team at CERN lead by Dave Pate (BNL)
- Welding procedure tested and verified at BNL and CERN (Steve Kane)
- Speed and professionalism of installation caught CERN by surprise
- Installation will be complete by end of March (all 64 sent to CERN already)
- Production of spares + cleanup will continue through May
- Slow controls+software not yet well understood

HV Feedthroughs

High density warm to cold connectors and filters for HV cables (2 FT per each cryostat)

US is providing:

HV feedthroughs for barrel and both endcap calorimeters

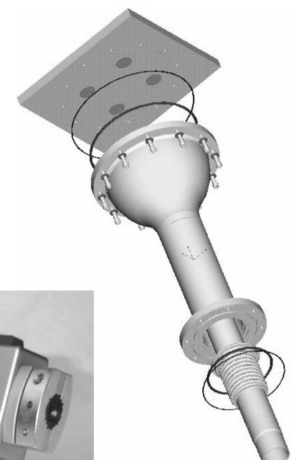
HV cables (8 x 840)

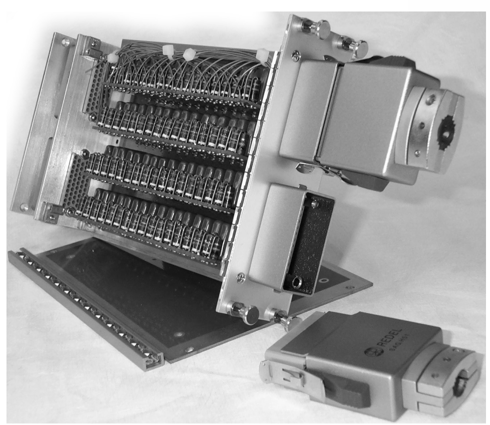
HV Filter box

Installation

Commissioning

Monitoring





HV Feedthroughs 2

Installation scheme changed:

- mechanical components installed on cryostat-together with signal FTs
- cables installed after module insertion (need clean environment)

Schedule driven by cryostats availability- barrel ready with 2 HVFT cans installed, but Endcap C cryostat is late (almost a year) and Endcap A cryostat will be produced after Endcap C's delivery.

Production of mechanical components almost complete
HV cables in production/testing (HV breakdown observed on some of the wires, cause/remedy under investigation)
Filter boxes in production
Monitoring/slow controls not addressed so far

Readout Electrodes

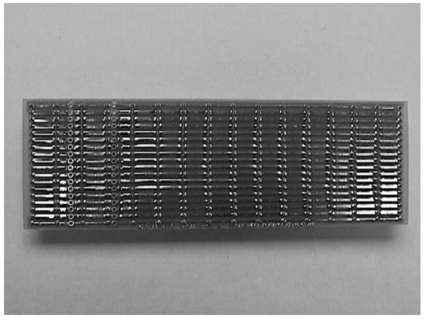
- Essential component of the em module production
- French/Italian/Spanish responsibility.
- US has a major financial obligation towards flat electrode procurement (managed by CERN)
- Production efficiency and schedule tightly coupled to the em module production and testing

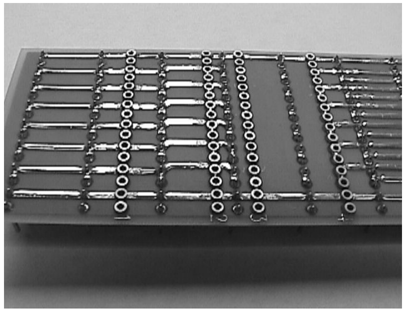
Status:

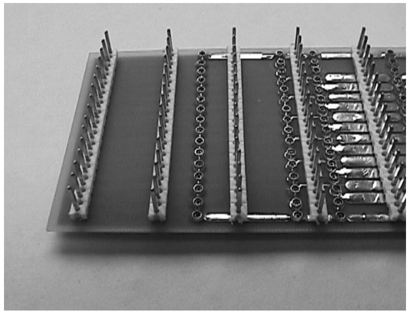
- 10 out of 32 em modules completed
- Accrued schedule delay (6-9 month) mitigated by opening a third testing station at CERN (in addition to Saclay and Marseille)

Mother Board System

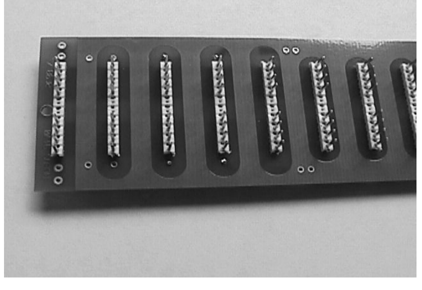
Summing boards, mother boards with calibration resistors and high voltage boards for HV distribution (over 25 different shapes)



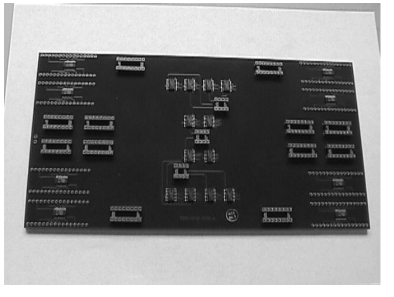




Summing Boards



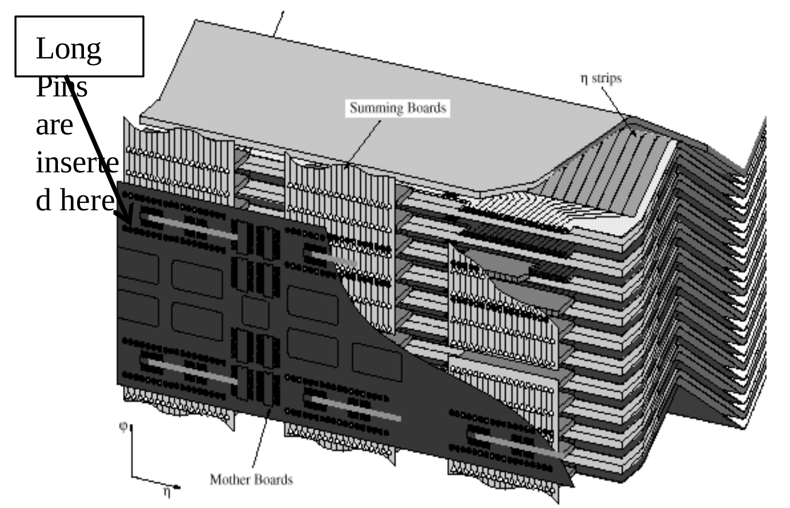
HV Boards



Mother Boards

Mother Board System 2

- Well organized production at BNL
- Delivery schedule matches module assembly needs
- Problem detected in Fall 01 during beam tests – sparking occurring in the module damages calibration resistor network
- Solution proposed by BNL: addition of diode protection circuit to each resistor network
- Produced by BNL in record time
- Need to retrofit ~6 modules (summer 02)
- Added cost



Readout electronics-Preamps

- US Responsibility: 50% Preamps for Barrel EM and Forward (120K channels)
- Production proceeds well. Expect some delay due to the need to sort hybrids to match the 1% gain precision requirements.

Test setup

Readout electronics -FEB

US provides:
Overall design barrel and endcaps, DSM design of Asics, ADC, 50% preamps, “Personality” cards, Asics production, cots, connectors, PCB, mechanical structures, fabrication and assembly testing, installation, commissioning
US is responsible for ~60% of the overall cost of front-end electronics.

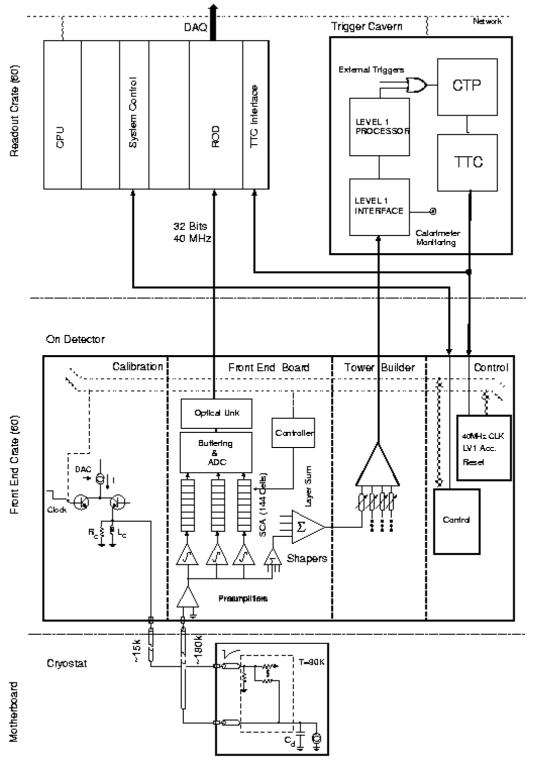
Concept – FEB is the same for all calorimeter
Practice - differences between barrel and endcaps
different parts of detector require different summations
Result - 25 different versions of the FEB

Readout electronics –FEB 2

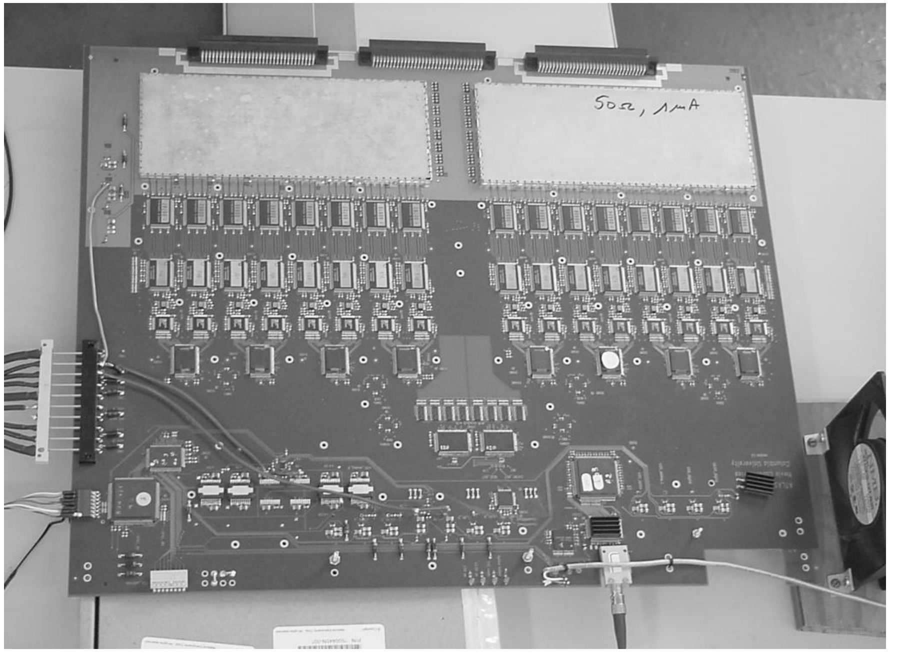
Very large system with many components
Overall coordination – John Parsons, Columbia
Progress during the last year:

- **Rearranged institutional responsibilities to match the design and follow-up Work**
- **Identified the non-committed financial responsibility as matching the cost of the spares and arranged for a CERN loan to be repaid by all LAr institutions from the M&O funds.**
- **Produced prototypes of 9 Asics in rad-hard technologies (DMILL+DSM),**
- **Assembled a "1/4 FEB" to study the interaction between the new Asics**
  - **→All work OK – (9 miracles)**
- **PRR successful on all Asics**
- **Integrated optical links onto FEB**
- **Generated a layout and assembled the first prototype board**

Readout electronics –FEB 3

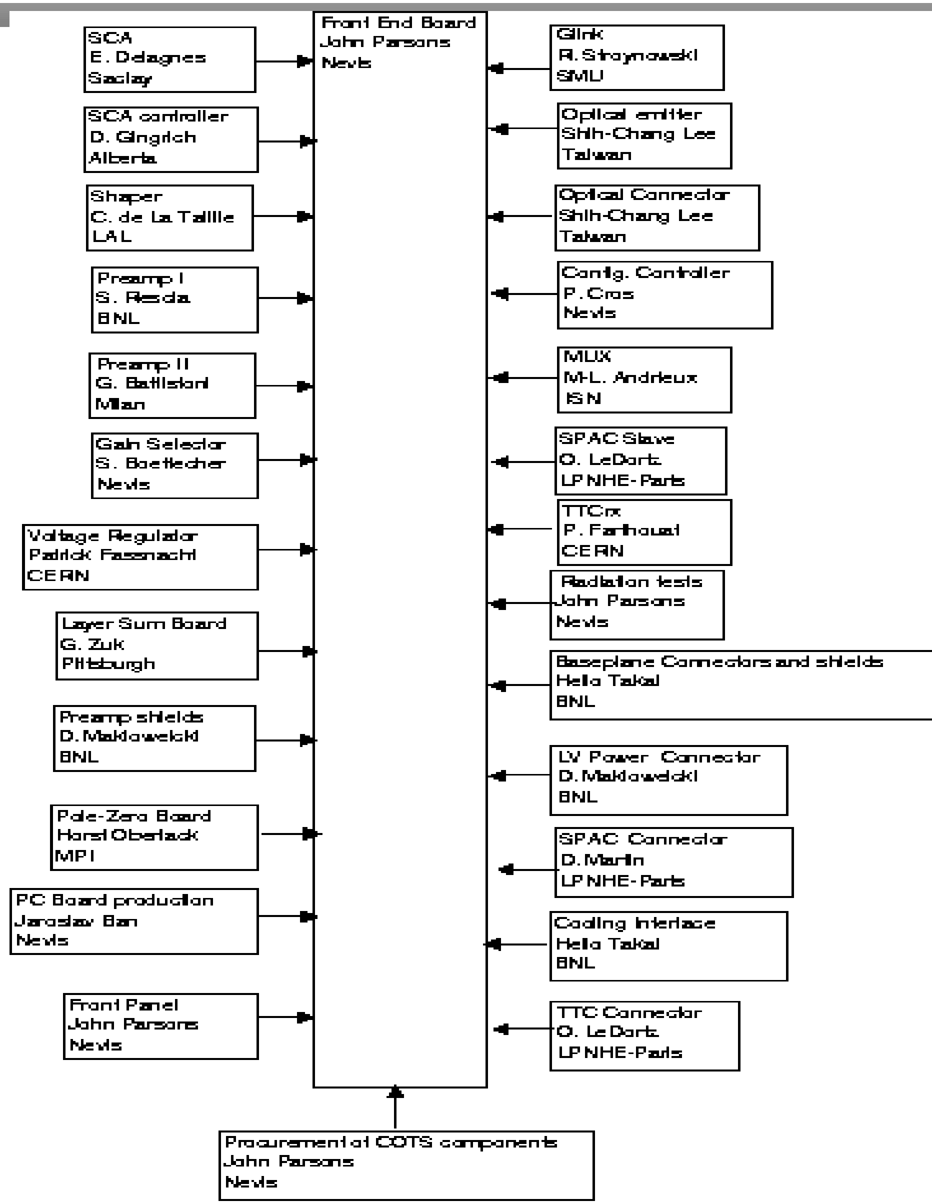


FEB Schematics



Production prototype no neg. VR’s

FEB Responsibility Chart



Readout electronics –FEB 4

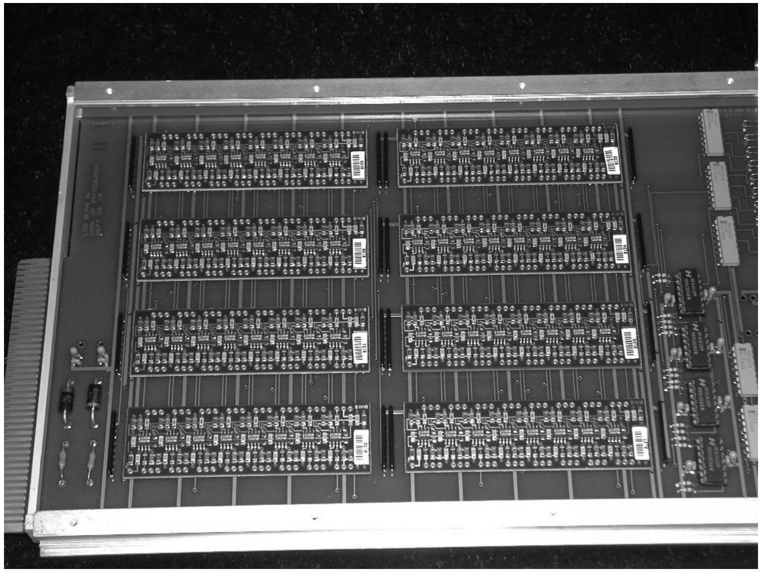
Main problematic missing components – rad hard voltage regulators
•CERN/Thompson design late by about one year.
•Prototype of positive voltage regulators exist. May have aging problem. Will need another version.
•Prototype of negative voltage regulators expected in April.

Next step – "Full crate test" → pre-production of 14-28 FEBs and 5 other boards sitting in the front crate. Must be successful before the PRR.
→ PRR schedule for December 02 is possible but very tight.

Readout electronics-layer sums

US is providing Personality Cards to be placed on FEB's (Bill Cleland –Pittsburgh)

Different parts of the calorimeter require different summation schemes. Several types of boards were designed for barrel and endcaps. Production started in Summer 2000 and is almost completed.



Optical Links

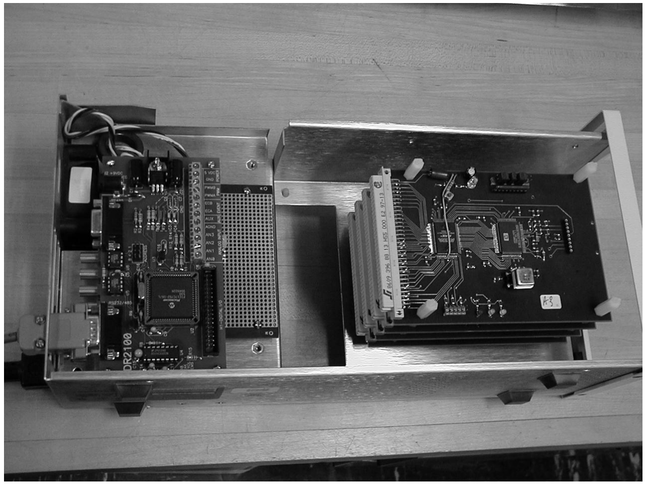
Provide data transfer between FEB and ROD:
Serializer, optical transmitter, fiber system, optical receiver, deserializer, control logic
US is providing (Jingbo Ye - SMU):
Overall design
G-links
FEB integration
ROD integration
Control software

Optical Links 2

All components are either COTS or COTS assemblies.
CERN requires – without much justification an extensive radiation testing program of each production batch and of each optoelectronics assembly. This results in a substantial cost increase.

Status –
transmitter integrated with FEB, pre-production test receiver design exist, ROD integration in 2003, G-links purchased, radiation tests are on-going.

Radiation test set-up



Readout Drivers (ROD)

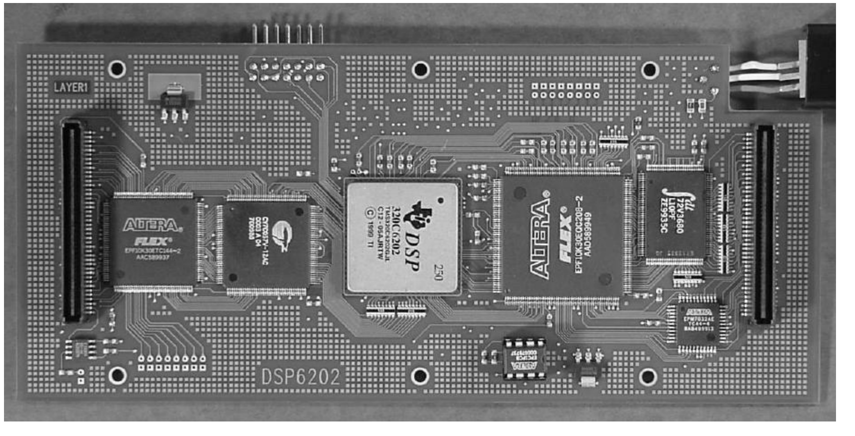
On-line DSP based processor system to extract energy and timing information at the input to DAQ, reduce data flow and implement calibration system. Design not yet completed. Production will have to be staged (see upgrade)

US provides:

Design (Columbia), testing (BNL, Stony Brook),50% processing units (upgrade), operational and control software (Stony Brook, SMU)

- **Demonstration system based on DSP (Texas Instruments) and consisting of a Mother Board (Geneva) and Processing Unit (Nevis) was built in 2000. It has been tested in the BNL and CERN test set-ups. New prototype based on TI64xx series under evaluation. PRR and construction responsibilities will be assigned in summer 02.**

Processing Unit



System Crate/Integration

US Responsibility:

All Barrel and EC electronics crates, Faraday cages, cooling plates, pedestals, warm cables, LV power supplies and power distribution, installation, commissioning.

Very large and diverse responsibility headed by Helio Takai, BNL.

- **Pedestal, Crate, Power Bus – in production. (Zober Industries).**
- **Base plane and warm cables– exist. Installation (summer 02) will follow feedthroughs installation (same team).**
- **LV Power Supplies – radiation resistant prototype from Modular Devices exist, full unit under construction. Design has redundancy of individual modules. Local shielding of magnetic field in the crate region OK. Production cost is in Management Contingency. Not all costs are covered by collaborators. Negotiations how to proceed are ongoing. Expect a conclusion and a request to release MC in Summer 02.**
- **Cooling plates – needed for FEB operations. Conceptual design complete, prototype tested. Japanese company producing early prototypes is no longer interested. New quotes are expected from an Italian manufacturer. Management Contingency conditionally released. Will have to renegotiate if price goes up. Selection of liquid not yet finalized (probably water).**

System Crate 2

- **System Studies: Full system (from “toy” calorimeter to ROD) working at BNL. Detailed system performance studies underway.**
- **Full size Mockup at CERN to study routing of cables and services.**
- **Proliferation of test setup requests**

→ **Working group (Cleland, Parsons) to define tests, locations and responsibilities.**
BNL remains a leading lab (Francesco Lanni).

Forward Calorimeter

US is providing (John Rutherfoord, Arizona):

Front sections of both FCals

Mother board system

Cold cables

Cold electronics

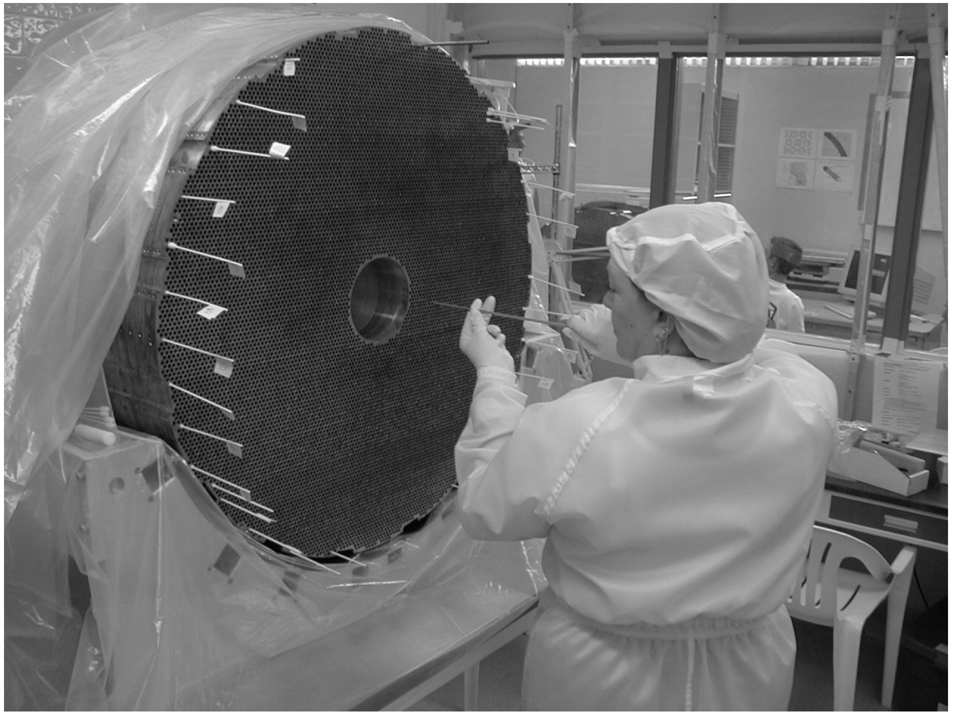
Trigger cables

Tower driver boards

Beam test module for
  calibration studies

Installation

Engineering support



Forward Calorimeter 2

Production proceeding well. Fcal C module completed in March. Production of Fcal A module already started. Production of cold electronics and cables is on-going.

Problems: Serious installation delays due to ~1 year delay in cryostat availability. Since the electronics is installed on the module after it is placed in the cryostat insertion tooling, this delay impacts the overall schedule.

Other activities

- **Level 1 Trigger receiver system (Pittsburgh –Cleland, Savinov)**

  Assignment of responsibility to Pittsburgh confirmed. Design started. Critical review planned for Summer 02. Production in 03.

- **Beam Tests**

  Very little US activities. New module test scheduled for June 02. SMU will have 3 days to study e/pi separation, multiple pion pileup and jet shapes.

  FCal tests scheduled for 03.

- **System Software**

  Little activities. Some work done on:

  Reconstruction (BNL), Simulations (Nevis, Arizona, SMU), Data Base (Nevis, BNL), Calibration Algorithms (BNL, Pittsburgh, Stony Brook), ROD software (Stony Brook, Nevis, BNL, SMU), FCal (Arizona), Radiation levels (Arizona).

  Although specialized software exist, it is difficult to establish the effects of the detector performance on physics/discovery quantities.

ETC02 Cost Comparison Liquid Argon WBS Level 3

(Project AYk$s)			
	Baseline Budget (ETC01 FY02-FY05 + Carryover)	Final ETC02 (FY02-FY05)	
WBS	**Budget (AYk$s)**	**ETC Budget (AY$s)**	**Delta**
131 Barrel Cryostat	1,527.3	1,494.0	33.3
132 Feedthroughs	1,575.0	1,607.6	(32.6)
133 Cryogenics	2,570.0	2,827.0	(257.0)
134 EM Electrodes/MB	1,739.5	1,611.7	127.8
135 Preamps/Calibration	1,124.2	682.0	442.2
136 System Crate	2,227.8	2,469.1	(241.3)
137 Front End Boards	6,586.3	6,718.8	(132.5)
138 Level 1 Trigger	1,459.2	1,415.0	44.2
139 Readout Drivers	379.4	357.0	22.4
1310 Forward Calorimeter	1,169.9	1,211.8	(41.9)
1311 Test Beams	599.7	576.0	23.7
Total	20,958.3	20,970.0	(11.7)

ETC02 Cost Comparison Explanations

- **No major change in overall cost for the system**

Cryostat - Small saving on cost of transport. Final repair cost not well known.

Feedthroughs - Extra cost for repairs of welding equipment and 2 FTs repairs.

Cryogenics - Contract cost with Air Liquide higher then expected

Electrodes - US bill paid with favorable currency exchange rate

Preamps - Smooth production, costs well established

System crate - Higher then expected development cost for radiation resistant power supplies

FEB - Additional requirements on radiation testing for COTS and additional development cost of ¼ FEB

Level 1 trigger - Design more mature

ROD - larger part of engineering covered by base program (Stefan Boetcher not replaced)

Fcal - additional trigger cables and small changes in cost of electronics

Test Beam - Less US activities

U.S. ATLAS

ETC02 Cost Profile
Liquid Argon – WBS Level 3

Liquid Argon ETC 02 Access Profile (Project K$s)

WBS	FY01	FY02	FY03	FY04	FY05	FY06	Total
131 Barrel Cryostat		926.6	349.4	197.1			1,473.1
132 Feedthroughs		1,526.5	78.9				1,605.4
133 Cryogenics		2,016.9	667.4	117.4			2,801.6
1341 Readout Electronics		944.5					944.5
1342 Motherboard System		667.2					667.2
135 Preamps/Cailbration		508.5	118.2	36.7	12.2		675.6
136 System Crate		1,932.2	303.2	213.2			2,448.6
137 Front End Boards		2,406.0	2,715.0	1,440.0			6,561.0
138 Level 1 Trigger		384.8	453.5	523.9	9.5		1,371.7
139 Readout Drivers		302.8	52.7				355.5
1310 Forward Calorimeter		841.6	154.4	200.1			1,196.1
1311 Test Beams		251.7	183.6	128.3			563.6
1.3 Total (FY02$s)	0.0	12,709.2	5,076.4	2,856.6	21.7	0.0	20,664.0
1.3 Total (AY$s)	0.0	12,709.2	5,218.5	3,018.9	23.6	0.0	20,970.3

Liquid Argon Milestones

Level 2 Milestones

Subsystem	Schedule Designator	Description	ETC 01 Schedule Date	ETC 02 Schedule Date
Liquid Argon	LAr L2/1	Cryostat Contract Award	Complete	Complete
	LAr L2/2	Barrel Feedthroughs Final Design Review	Complete	Complete
	LAr L2/3	Start Elec.'s Production (Preamps)	Complete	Complete
	LAr L2/4	FCAL Mech Design Complete	Complete	Complete
	LAr L2/5	FEB SCA Prod Chip Submission/Contract Award	19-Jul-01	N/A
	LAr L2/6	Level 1 Trigger Final Design Complete	4-Oct-01	30-Mar-02
	LAr L2/7	ROD Final Design Complete	12-Dec-02	12-Dec-02
	LAr L2/8	MB System Production Complete	30-Jun-02	30-Sep-02
	LAr L2/29	Cryostat Arrives at CERN	15-May-01	Complete
	LAr L2/10	Barrel Feedthroughs Production Complete	15-Feb-02	1-Jun-02
	LAr L2/11	FCAL-C Delivered to EC	17-Oct-02	15-Jan-03
	LAr L2/12	FCAL-A Delivered to EC	8-Dec-03	4-Nov-03

Liquid Argon Milestones

Level 3 Milestones (Goals)

Subsystem	Schedule Designator	Description	ETC 01 Schedule Date	ETC 02 Schedule Date	
Liquid Argon	LAr L3/1	Barrel Cryostat	31-Aug-01	Complete	
	LAr L3/2	Signal Feedthroughs	11-Nov-02	2-Dec-02	
	LAr L3/3	HV Feedthroughs	30-Dec-02	30-Sep-03	
	LAr L3/4	Readout Electrodes	31-Dec-02	31-Dec-02	
	LAr L3/5	MB System	30-Jun-02	30-Sep-02	
	LAr L3/6	Pedestal	30-Dec-01	30-Oct-02	
	LAr L3/7	Cables/Base Plane	30-Oct-02	30-Oct-02	
	LAr L3/8	Mechanical Crate	30-Oct-02	30-Oct-02	
	LAr L3/29	Power Supplies	1-Sep-04	1-Sep-04	
	LAr L3/10	Front End Boards	3-Aug-04	19-Oct-04	
Off-Detector Electronics					
	LAr L3/11	Level 1 Interface	2-Aug-04	30-Sep-04	
	LAr L3/12	ROD System	6-Dec-04	6-Dec-04	Note 1:
FCAL Mechanical	LAr L3/13	FCAL Module	8-Dec-03	4-Nov-03	

Note 1: On the schedule there is a Production II and Installation II activities with a completion date of June 8, 2007.

Liquid Argon Milestones

Level 4 Milestones (Baseline Scope)

WBS	Schedule Designator	U.S. ATLAS Responsibility Completion Description	ETC 01 Baseline Scope Completion Date	ETC 02 Baseline Scope Completion Date	ATLAS Required Date	ETC 02 Planned Float (Months)
LAr						
1.3.1	LAr L4/1	Cryostat Final Accep Test Compl	8/01	Complete	11/01	N/A
1.3.2	LAr L4/2	Signal FT Installation Compl	11/02	12/02	10/02	**-2**
	LAr L4/3	HV FT End-Cap C Install Compl	2/02	9/02	11/01	**-10**
	LAr L4/4	HV FT Barrel Install Compl	11/01	5/02	5/02	**0**
	LAr L4/5	HV FT End-Cap A install Compl	12/02	9/03	9/02	**-12**
1.3.3	LAr L4/6	LAr Cryogenics Vendor Install Compl	9/03	9/03	12/03	**3**
1.3.4.1	LAr L4/7	Last Del of Readout Electrodes	12/02	12/02	10/02	**-2**
1.3.4.2	LAr L4/8	MBs Ship to Annecy,Saclay (France)	6/02	9/02	9/02	**0**
1.3.5.1	LAr L4/9	Preamp Deliveries to FEB Compl	5/03	5/03	3/04	10
1.3.5.2	LAr L4/10	Prec Calor Calib Production Complete	N/A	N/A	N/A	N/A
1.3.6.1	LAr L4/12	Pedestal Ship to CERN Compl	12/01	10/02	7/03	9
	LAr L4/13	Barrel Ship to CERN Compl	12/01	10/02	3/03	5
1.3.6.2	LAr L4/14	Cables Shipping Complete	10/02	10/02	3/03	5
	LAr L4/15	Baseplane Last Delivery to CERN Compl	10/02	10/02	3/03	5
1.3.6.3	LAr L4/16	EC Crates Last Delivery to CERN Compl	10/02	10/02	3/03	5
	LAr L4/17	Barrel Crates Last Delivery to CERN Compl	10/02	10/02	3/03	5
1.3.6.4	LAr L4/18	Controls Ship to CERN Complete	9/03	9/03	5/04	8
1.3.6.5	LAr L4/21	Thermal Contacts (Proto) Last Delivery Compl	9/02	9/02	9/02	**0**
1.3.7.1	LAr L4/22	FEB Last Delivery Complete	8/04	10/04	1/05	3
1.3.7.2	LAr L4/23	SCAs Last Delivery to FEB Compl	N/A	N/A	N/A	N/A
1.3.7.4	LAr L4/24	Last Driver Delivery to FEB Compl	4/04	4/04	5/04	1
1.3.8.1	LAr L4/26	Layer Sums Last Delivery to FEB Compl	12/02	12/02	3/04	3
1.3.8.2	LAr L4/27	I/F to Level 1 Ship to CERN Complete	8/04	9/04	12/04	3
1.3.9	LAr L4/28	ROD System Final Prototype Complete	8/02	8/02	8/02	**0**
1.3.10	LAr L4/29	Deliver Finished FCAL-C to EC	10/02	1/03	10/02	**-3**
	LAr L4/30	Deliver Finished FCAL-A to EC	12/03	11/03	11/03	**0**
	LAr L4/31	FCAL Elec.'s Summ Bds Ready for Installation	12/01	2/02	2/02	**0**
	LAr L4/32	FCAL Elec.'s Cold Cables Testing Complete	11/01	10/01	2/02	4

Cost and Schedule Status (as of 12/01)

- **Major elements of the Plan for this year**
  - **Full crate test of front-end readout electronics followed by PRR for the FEB**
  - **Complete production of motherboards and preamps**
  - **Complete barrel cryostat installation including signal and HV feedthroughs and pedestals**
  - **Initiate crate system production**

Installation

- All installation costs are are either included in the project cost or are in the Management Contingency. The amount still in Management Contingency is relatively small.
- For the case of readout electronics installation (plugging boards in and checking that signals go through) will overlap with commissioning (checking quality of signals, correct cabling, etc)
- FCal installation cost is contingent on the availability of the endcaps cryostats and tooling. The continuing slippage of their schedule is worrisome.

Conclusions

Substantial progress in production and installation of LAr elements.

Mechanical components (Cryostat, FTs, Fcal) are either close to completion or in a well advanced production.

Readout electronics has had several “miracles” so far.

Design of ROD, Level 1 trigger proceeds well.

Potential worries: endcap cryostat deliveries, voltage regulators, relaxation of the CERN schedule affecting installation

Liquid Argon Maintenance and Operations; Upgrade R&D

Richard Stroynowski

SMU

M&O Concept

LAr must be complete at the start of the experiment (required by mechanics of installation + initial physics) → full installation is a necessary part of the project.

Commissioning belongs to M&O

Procedure for bottom-up M&O estimate

- Follow US construction responsibilities
- Identify Liquid Argon subsystems
- For each subsystem estimate the need for
    - Supervisory physicist (base)
    - Senior engineer
    - Technician/junior engineer
    - Software professional
    - Frequency of interactions needed
- Identify institutions which are willing to take on the responsibility
- FEB spares

Pre-operations

Calorimeter installation sequence:

•Initial installation in Building 180. 3 separate cryostats.

•Signal, HV FT and pedestals installed in 2002

•Calorimeter modules installed and cabled in 2003

•Systems cooled down and tested in 2003/2004

•Transfer from 180 to ATLAS pit in 2004

•Installation of final cryogenics system+commissioning

•Installation of Front End crates and electronics in 2005

Pre-operations 2

US responsibilities during the pre-operations will consist of

•Mechanical –

contribution to the operations of the cryogenic systems (pumps, sensors, monitors, consumables)

contribution to the HV and signal FT operations

contribution to the transport (assumed at 20%) of the total

contribution to the pit installation and commissioning

update of the documentation (separate for operations in bldg 180 and in the pit)

creation of the operations slow control data base (pressure, temperature, liquid levels, gas flow)

Pre-operations 3

•Combined EMEC/HEC/Fcal beam test to calibrate tails of hadronic showers. Will require construction of special Fcal module to fit into the test cryostat.

•Long term burn-in of the Front-end system crate. (pre-production complete crate of the front electronics will be operational 2004-2006) for study of the performance, noise and ROD integration problems.

•FEB spares – 20% of the CERN loan.

•Contribution to the common costs (assumed at 20% of the total) for maintenance of the bldg.180, equipment rental and general operations.

Operations

•Primary US responsibilities for maintenance and operations follow US deliverables.

•In addition to the contribution to the day-by-day operations organized by personnel located at CERN and assumed to be at 20% of the total collaboration contribution to LAr, US must maintain the technical capability for testing and repairs of both mechanical components and of electronics components e.g., personnel located at CERN will be able to identify and replace a malfunctioning FEB, but any detailed repair will have to be done at Nevis.

•Maintenance of the operations data bases for systems with large number of computers will require software professionals.

•Each system will require fraction (depending on complexity) of an engineer, technician, software professional and supervisory physicist.

FEB Spares

Project (and original MOU) covers only the number of FEBs needed for the experiment. There is a need for spares during the operations of ATLAS. For practical and economic reasons it is cheaper to produce spares together with the all other FEBs. A CERN loan has been arranged to cover the cost and will be repaid by all LAr collaboration. US share is ~$312k and the re-payment is scheduled for 2005/2006.

Manpower estimates

	MANPOWER ESTIMATE SUMMARY IN FTEs											
	WBSNo:	3.3	Funding Typ	Project	##########							
	Description:	Liquid Argon	Institutions:	All	Funding Sou	All						
	Calcu-											
		Entered										
	FY03	*FY04*	*FY05*	*FY06*	*FY07*	*FY08*	*FY09*	*FY10*	*FY11*	*FY12*	*lated*	
	Total											
Faculty	0	0		7	7	7	7	7	7	7		
Sr Research	0	0										
Term Scienti	0	0										
Post Doc	0	0	0	6	6	6	6	6	6	6		
Grad Studen				8	8	8	8	8	8	8		
Mechanical E	0.1	0.4	1.6	1.3	1.8	1.8	1.8	1.8	1.8	12.2	0	
Electrical Eng	1.1	1.4	0.4	4.4	4.4	4.4	4.4	4.4	4.4	29.1	0	
Technician	0.5	2.7	2.3	0.5	4.1	4.1	4.1	4.1	4.1	4.1	30.2	0
Computer	1.3	3.7	3.3	4.8	4.8	4.8	4.8	4.8	4.8	36.7	0	
Designer	0.3	1.5	0.2	0.3	2.2	0						
Administrato	0	0										
Contract Lab	0	0	0									
TOTAL LAB	0.9	6.9	7.5	6	14.5	14.9	14.9	14.9	14.9	14.9	110.5	0

Top 5 lines represent base support
Total refers to the project only

M&O Profile 1

U.S. ATLAS M&&O Estimate

WBS Profile Estimates

Funding Source: All **Funding Type:** Project 3/18/02 11:42:53 AM

Institutions All **Labor/Material:** Both

	WBS Number	FY 03 Descriptio	FY 04 (k$)	FY 05 (k$)	FY 06 (k$)	FY 07 (k$)	FY 08 (k$)	FY 09 (k$)	FY 10 (k$)	FY 11 (k$)	FY 12 (k$)	Total (k$)	(k$)
3.3	Liquid Argon M&O Estimate		273	991	1347	1414	3163	3323	3479	3479	3479	3479	24425
	3.3.1	Pre operations and Commissioning	207	817	670	258	0	0	0	0	0	0	1952
	3.3.1.1	Electronics pre operations and	0	692	658	122	0	0	0	0	0	0	1472
	3.3.1.1.1	Documentation Update	0	432	0	0	0	0	0	0	0	0	432
	3.3.1.1.1.1	Documentation Update	0	111	0	0	0	0	0	0	0	0	111
	3.3.1.1.1.2	Documentation update	0	202	0	0	0	0	0	0	0	0	202
	3.3.1.1.1.3	Documentation update	0	71	0	0	0	0	0	0	0	0	71
	3.3.1.1.1.4	Documentation update	0	48	0	0	0	0	0	0	0	0	48
	3.3.1.1.2	Integration	0	96	0	0	0	0	0	0	0	0	96
	3.3.1.1.3	Facilities	0	111	0	0	0	0	0	0	0	0	111
	3.3.1.1.4	Commissioning	0	52	658	122	0	0	0	0	0	0	832
	3.3.1.1.4.1	Commissioning System Crate	0	0	272	0	0	0	0	0	0	0	272
	3.3.1.1.4.2	Commissioning Optical links	0	0	105	0	0	0	0	0	0	0	105
	3.3.1.1.4.3	Commissioning ROD System	0	0	160	0	0	0	0	0	0	0	160
	3.3.1.1.4.3.1	Commissioning ROD	0	0	102	0	0	0	0	0	0	0	102

M&O Profile 2

WBS	FY 03	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	Total	
Number	**Descriptio**	**(k$)**	**(k$)**	**(k$)**	**(k$)**	**(k$)**	**(k$)**	**(k$)**	**(k$)**	**(k$)**	**(k$)**	**(k$)**
3.3.1.1.4.3.2	**Commissioning ROD**	0	0	30	0	0	0	0	0	0	0	30
3.3.1.1.4.3.2.1	0	0	0	0	0	0	0	0	0	0	0	
3.3.1.1.4.3.3	**Commissioning ROD**	0	0	28	0	0	0	0	0	0	0	28
3.3.1.1.4.4	**Long Term B.I.**	0	52	52	52	0	0	0	0	0	0	157
3.3.1.1.4.5	**Commissioning Receiver.**	0	0	69	69	0	0	0	0	0	0	139
3.3.1.2	**Mechanics pre operations and**	207	126	12	136	0	0	0	0	0	0	481
3.3.1.2.1	**Documentation Update**	30	0	12	136	0	0	0	0	0	0	178
3.3.1.2.1.1	**Documentation Update**	0	0	12	0	0	0	0	0	0	0	12
3.3.1.2.1.2	**Documentation update**	26	0	0	117	0	0	0	0	0	0	143
3.3.1.2.1.3	**Documentation update**	4	0	0	19	0	0	0	0	0	0	23
3.3.1.2.2	**Facilities**	97	3	0	0	0	0	0	0	0	0	101
3.3.1.2.3	**fcal Hadronic Tail Measurement**	80	122	0	0	0	0	0	0	0	0	202
3.3.2	**Operations**	0	0	201	557	1091	1091	1091	1091	1091	1091	7304
3.3.2.1	**Electronics Operations**	0	0	201	201	732	732	732	732	732	732	4792
3.3.2.1.1	**Operations electronics**	0	0	0	0	139	139	139	139	139	139	836
3.3.2.1.2	**Operations Software Support**	0	0	201	201	592	592	592	592	592	592	3955
3.3.2.1.2.1	**Operations Software Support**	0	0	0	0	182	182	182	182	182	182	1092
3.3.2.1.2.2	**Operations Software Support**	0	0	0	0	209	209	209	209	209	209	1253
3.3.2.1.2.3	**Operations Software Support**	0	0	201	201	201	201	201	201	201	201	1610
3.3.2.1.3	**Operations Physicist support**	0	0	0	0	0	0	0	0	0	0	0
3.3.2.1.3.1	**Operations Physicist support**	0	0	0	0	0	0	0	0	0	0	0
3.3.2.1.3.2	**Operations Physicist support**	0	0	0	0	0	0	0	0	0	0	0
3.3.2.1.3.3	**Operations Physicist support**	0	0	0	0	0	0	0	0	0	0	0

U.S. ATLAS

M&O Profile 3

Number	Descriptio	(k$)	(k$)	(k$)	(k$)	(k$)	(k$)	(k$)	(k$)	(k$)	(k$)	(k$)
3.3.2.1.3.4	**Operations Physicist support**	0	0	0	0	0	0	0	0	0	0	0
3.3.2.1.3.5	**Operations Physicist support**	0	0	0	0	0	0	0	0	0	0	0
3.3.2.2	**Mechanical operations**	0	0	0	355	359	359	359	359	359	359	2512
3.3.2.2.1	**Mechanical operations cryostat**	0	0	0	53	53	53	53	53	53	53	370
3.3.2.2.2	**Mechanical operations Quality**	0	0	0	80	80	80	80	80	80	80	563
3.3.2.2.3	**Mechanical operations**	0	0	0	154	154	154	154	154	154	154	1080
3.3.2.2.4	**Mechanical operations HV**	0	0	0	7	11	11	11	11	11	11	76
3.3.2.2.5	**Mechanical operations FCAL**	0	0	0	61	61	61	61	61	61	61	424
3.3.3	**Maintenance**	17	147	307	313	1667	1743	1899	1899	1899	1899	11789
3.3.3.1	**Maintenance of electronic**	12	25	175	181	1486	1500	1656	1656	1656	1656	10004
3.3.3.1.1	**Maintenance of electronic front**	0	0	150	156	262	276	432	432	432	432	2572
3.3.3.1.2	**Maintenance of electronic Level**	7	0	0	0	33	33	33	33	33	33	208
3.3.3.1.3	**Maintenance of the ROD**	0	0	0	0	327	327	327	327	327	327	1960
3.3.3.1.3.1	**Maintenance of the ROD**	0	0	0	0	327	327	327	327	327	327	1960
3.3.3.1.3.2	**Maintenance of the ROD**	0	0	0	0	0	0	0	0	0	0	0
3.3.3.1.4	**Maintenance of the Power**	0	0	0	0	359	359	359	359	359	359	2153
3.3.3.1.5	**Maintenance of the Optical Links**	0	0	0	0	179	179	179	179	179	179	1074
3.3.3.1.6	**Maintenance of the Crates**	4	0	0	0	17	17	17	17	17	17	106
3.3.3.1.7	**Maintenance of the DCS and**	0	0	0	0	284	284	284	284	284	284	1706
3.3.3.1.8	**Maintenance of the Electronics**	0	25	25	25	25	25	25	25	25	25	225
3.3.3.2	**Maintenance of mechanical**	5	122	132	132	181	243	243	243	243	243	1785
3.3.3.2.1	**Maintenance of the Cryogenics**	0	39	42	42	74	91	91	91	91	91	652
3.3.3.2.2	**Maintenance of the Quality**	0	65	68	68	84	117	117	117	117	117	870

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M&O Profile 4

WBS Number	FY 03 Descriptio	FY 04 (k$)	FY 05 (k$)	FY 06 (k$)	FY 07 (k$)	FY 08 (k$)	FY 09 (k$)	FY 10 (k$)	FY 11 (k$)	FY 12 (k$)	Total (k$)	(k$)
3.3.3.2.3	**Maintenance of the HV**	0	13	17	17	17	30	30	30	30	30	213
3.3.3.2.4	**Maintenance of the mechanical**	5	5	5	5	5	5	5	5	5	5	50
3.3.4	**CERN living expenses**	0	0	120	120	120	180	180	180	180	180	1260
3.3.5	**CERN common costs**	49	27	48	166	285	309	309	309	309	309	2120
3.3.5.1	**CERN common costs**	49	27	48	166	285	309	309	309	309	309	2120

Upgrades

•ROD upgrade:

Initially, ROD will have 100% of mother boards but only 50% of processing units. Layout will allow for channeling of the data from two FEB to one PU. The processing unit will not be able respond in time and the trigger rate will have to be reduced. ROD upgrade will consists of construction of the remaining 50% of PUs and changes to the FPGA software to recover full processing capability. This upgrade is planned for 2005-2007.

Upgrades 2

•FEB upgrade

CERN plans include upgrade of the LHC luminosity by a factor of 10. This will result in a corresponding increase of radiation levels in the area of front end crate and the presently designed readout boards will not survive. This upgrade includes a 4 year R&D on the design of electronics that can work in much higher radiation environment. The cost of construction of such new system is not included. It is difficult to estimate at this stage. It is likely to be comparable to the cost of components of the present front-end board which is in excess of $6M.

Upgrade manpower

MANPOWER ESTIMATE SUMMARY IN FTEs

WBSNo: 4.3Funding Type: Project10/17/01 10:25:05 AM

Description:No description on file.Institutions: AllFunding Source :All

Calcu-

Entered

FY03	*FY04*	*FY05*	*FY06*	*FY07*	*FY08*	*FY09*	*FY10*	*FY11*	*FY12*	*lated*		
Total												
Computing	.5	1.5	.5	.5	.5	.5	4.0	.0				
Electrical Engineer Sr	2.1	2.1	2.0	2.0	2.0	2.0	12.2	.0				
Electrical Engineer Jr	.0	.0										
Mechanical Engineer Sr	.2	.2	.5	.9	.0							
Mechanical Engineer Jr	.0	.0										
Design - Draft	1.1	3.0	3.0	2.0	9.1	.0						
Adm Support	.0	.0										
Electrical Technician	1.0	5.0	5.0	2.5	2.0	2.0	17.5	.0				
Mechanical Technician	.3	.3	.0									
Student	.0	.0										
Physicist	.0	.0										
Purchased Labor	.0	.0										
TOTAL LABOR	.0	4.9	11.8	11.3	7.0	4.5	4.5	.0	.0	.0	44.0	.0

Upgrade profile

Upgrades to U.S. ATLAS
WBS Profile Estimates

Funding Source: All **Funding Type:** Project 10/17/01 10:25:50 AM
Institutions All

WBS Number	Description	FY 03 (k$)	FY 04 (k$)	FY 05 (k$)	FY 06 (k$)	FY 07 (k$)	FY 08 (k$)	FY 09 (k$)	FY 10 (k$)	FY 11 (k$)	FY 12 (k$)	Total (k$)
4.3		**0**	**50**	**200**	**700**	**613**	**250**	**250**	**0**	**0**	**0**	**2063**
4.3.1	**Upgrades**	0	50	200	700	613	250	250	0	0	0	2063
4.3.1.1	**FEB Upgrade**	0	50	200	0	250	250	250	0	0	0	1000
4.3.1.2	**ROD Upgrade**	0	0	0	0	363	0	0	0	0	0	363
4.3.1.3	**Cryogenic Upgrade**	0	0	0	700	0	0	0	0	0	0	700

M&O Flexibility

- **There is very little flexibility in the M&O needs in the early years. The cryostats will operational and the detector modules installed. The calorimeter will be completed (minus the readout electronics) in bldg.180. The cost of its operations needs to be supported by pre-operations M&O. Similarly – some of the electronics commissioning (Fcal) starts in FY04.**
- **Small amounts of costs related to documentation (10-15% for FY03+FY04) can be deferred.**
- **The consequences of no support in FY03+FY04 depend on long term plan. I expect that fraction of operational costs can be deferred via loans or negotiations as long as they are paid back. Commissioning of electronics is within US responsibility and cannot be deferred.**